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The Characteristics and Causes of Ionospheric Irregularities Utilizing Drift Scintillation Meters

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This is the final report for the subject contract under which the University of Texas at Dallas (UTD) built, tested and delivered four flight versions of the Drift Scintillation Meter (DSM2) to the Geophysics Laboratory for flight on Air Force DMSP satellites. The report is divided into three sections. Section 1 contains the instrument description and theory of operations. Section 2 contains a description of spacecraft-level instrument testing, stimulation requirements and instrument handling and safety. Section 3 contains an instrument interconnection diagram and a list of the schematics, drawings, parts lists and wiring lists that describe the as-built configuration of the instrument. This documentation is available to GL upon request. Test results, calibration data and procedures are found in the R&D Equipment Information Reports that were submitted to GL after each instrument delivery.

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Preface

This is the Final Report for the subject contract under which The University of Texas at Dallas (UTD) built, tested and delivered four flight versions of the Drift Scintillation Meter (DSM2) to the Geophysics Laboratory for flight on Air Force DMSP satellites. The report is divided into three sections. Section 1 contains the instrument description and theory of operation. Section 2 contains a description of spacecraft level instrument testing, stimulation requirements and instrument handling and safety. Section 3 contains an instrument interconnection diagram and a list of the schematics, drawings, parts lists and wiring lists that describes the as-built configuration of the instrument. This documentation is available to GL upon request. Test results, calibration data and procedures are found in the R&D Equipment Information Reports that were submitted to GL after each instrument delivery.

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Related Contracts

UTD has completed Air Force contracts F19628-82-K-0041, "An Improved Ion Drift Meter", and F19628-79-C-0108, "The Characteristics and Causes of Ionospheric Irregularities". Contract number F19628-88-C-0046 is still active at UTD.

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Referenced Illustrations

SECTION 1

INSTRUMENT DESCRIPTION

1.0 GENERAL

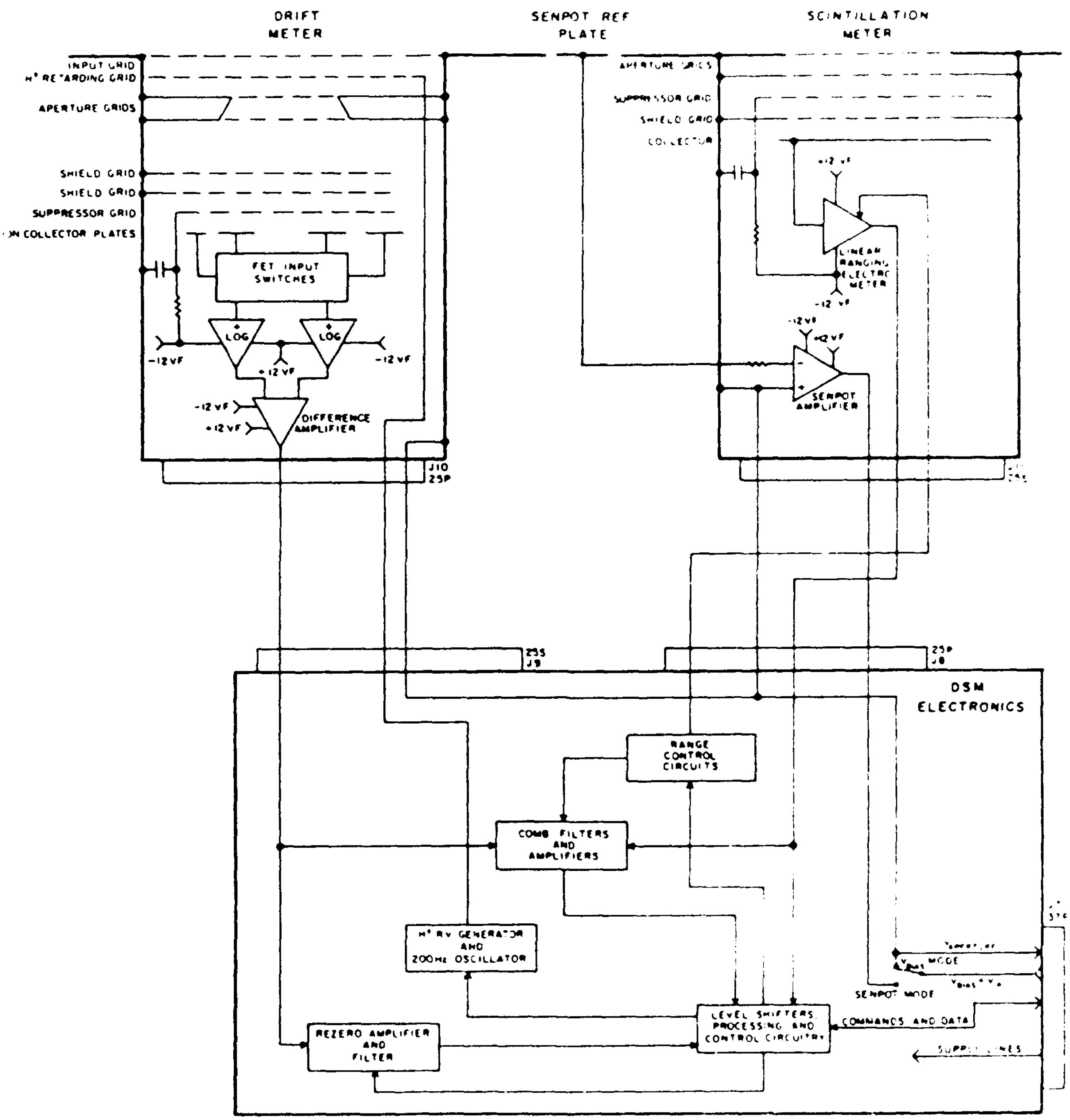
The Drift Scintillation Meter (DSM2) consists of a Drift Meter sensor, a Scintillation Meter sensor and an electronics box, as shown in Figure 1. The Drift Meter sensor and the Scintillation Meter sensor are mounted in a common mount and share a common aperture plane with the GL SSIES Ion (RPA) sensor. The DSM2 electronics box interconnects to the SSIES electronics box. Electrometer amplifiers are located in each sensor and the sensors connect to the DSM2 electronics box via GL-supplied cables. The DSM electronics box receives regulated voltages, digital commands, and timinsignals from the SSIES and outputs analog data on three lines to the SSIES. The three analog outputs are A/D converted by a 9 bit A/D converter. Figure 2 illustrates the time relationship for the sampling of the three outputs. The data collected each second from the three channels is sequentially telemetered as shown in Figure 2A. The three outputs and their sampling frequencies are:

(1.) Electrometer/Amplifier (E/A) - 24 samples/sec.

(2.) Drift Meter (DM) - 12 samples/sec.

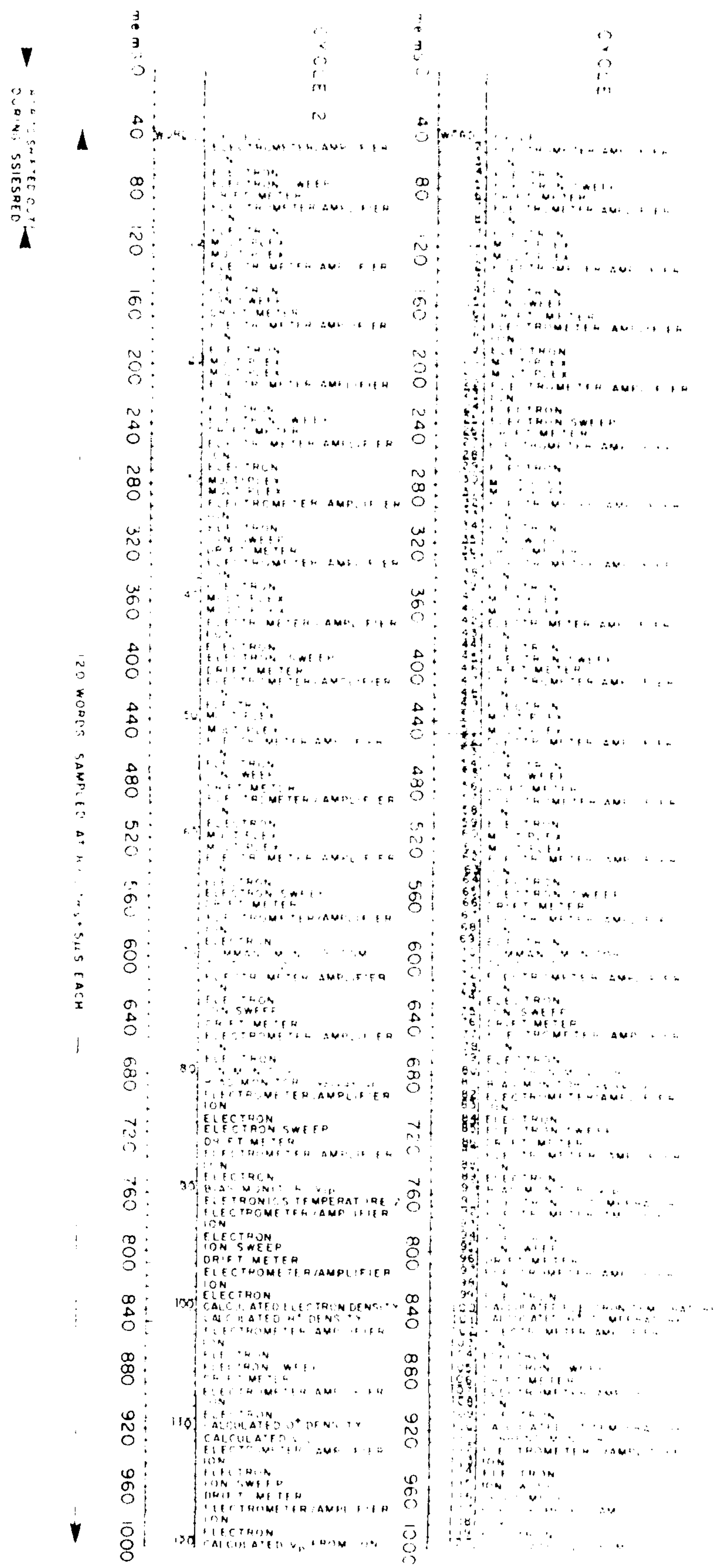
(3.) Multiplex (MUX) - 12 samples/sec.

Since the DMSP satellite solar panels have a negative ground, the spacecraft can acquire a large negative potential in sunlight, thus requiring that the sensors be isolated from the spacecraft chassis and driven to a potential near the ambient plasma potential. A sensor potential circuit (SENPOT) that senses the ambient plasma potential and drives the sensors to a desirable potential ($V_{aperture}$) near that of the ambient plasma is provided as an auxiliary means of establishing the sensor potential. The SENPOT device is described in detail by Zuccaro and Holt (1982).[1]



DSM2
FUNCTIONAL DIAGRAM

Figure 1



DSM2 DATA SAMPLE TIMES

Figure 2

SSIES - 2 DOWNLINK FORMAT

MARCH 1[illegible] 1986

WORD												
1-12	CYCLE 1 ID CYCLE 2 ID	CONFIG 1 ID CONFIG 2 ID	CMD MON OLS CMD MON DSM	CURRENT MONITOR TEMP. MONITOR	RPA Thermistor ELECTRON Thermistor	Vaperture MONITOR Bias MONITOR	RPA ION MONITOR SPARE	T_{H+} N_{H+}	T_{O+} N_{O+}	V_P RPA V_{SP}	ELECTRON MONITOR V_P ELE	T_E N_E
13-24	RPA ION ..											
25-36	RPA ION ..											
37-48	DSM (ELE/AMP)											
49-60	DSM (DRIFT)											
61-72	DSM (Multiplex)											
73-84	DSM (ELE/AMP)											
85-96	ELECTRON ..											
97-108	ELECTRON ..											
109-120	RPA SWEEP						ELECTRON SWEEP					

PRR1 SSIES-2 FORMAT

PROPOSED REDUCTION IN DOWNLINK DATA

.. ION AND ELECTRON DATA CAN BE INTERCHANGED BY COMMAND

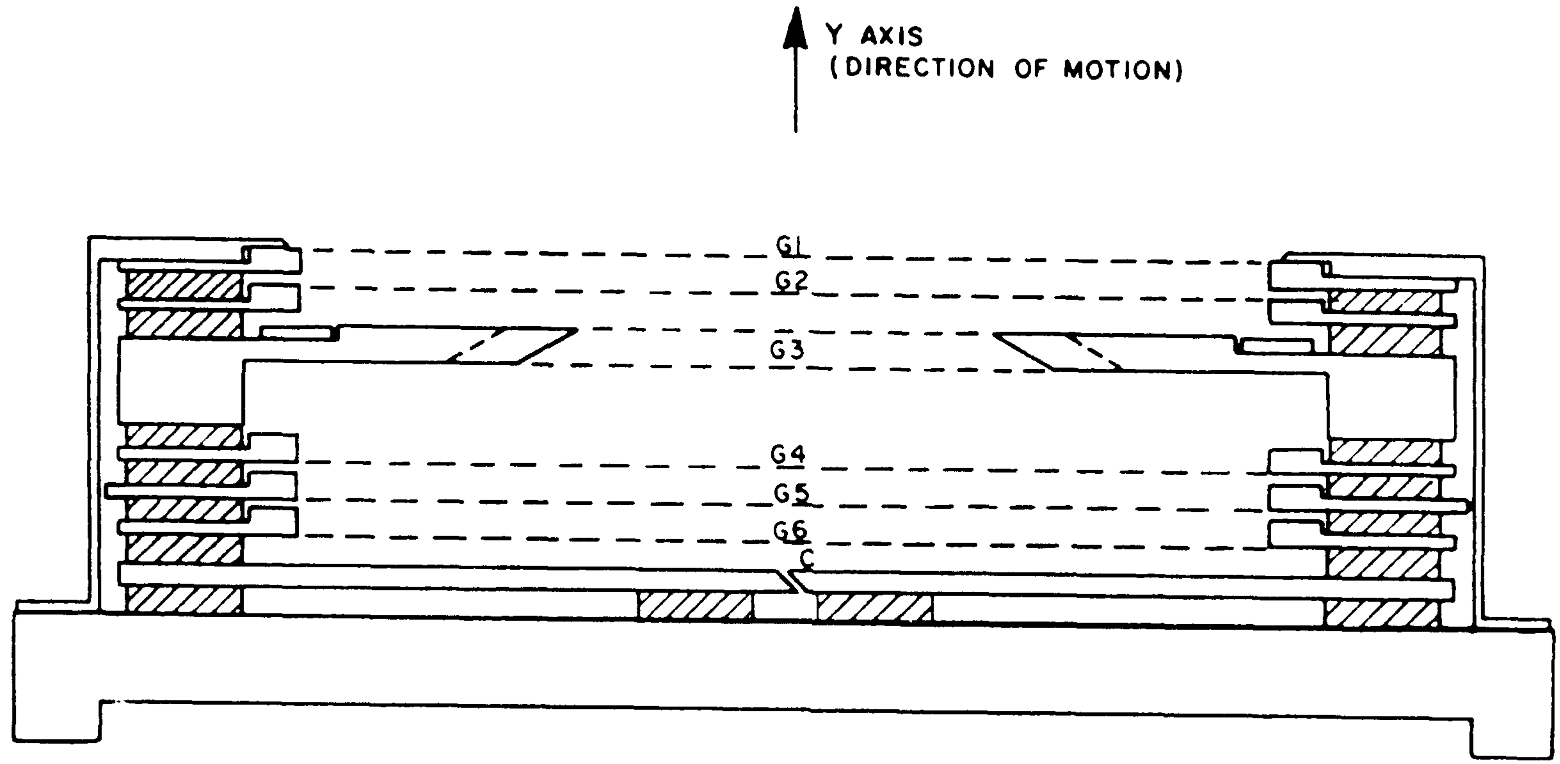
Figure 2A

2.0 PRINCIPLES OF OPERATION

2.1. Drift Meter

The Drift Meter (DM) employs a gridded collimator and segmented collectors to determine the angle between the normal to the collector and the arriving particle beam. From this information and a knowledge of the spacecraft attitude and velocity, the ambient drift velocity vector in a plane parallel to the collector surface can be determined. The gridded collimator and collectors are shown in cross-section in Figure 3. The entrance grid G1, the double collimator grid G3, the sensor outer shell, and the aperture plane in which the sensors are mounted are connected to sensor ground ($V_{aperture}$) during all operations. The repeller grid G2 may have different potentials applied to it depending upon the mode of the instrument. The shield grids G4 and G5 are held at $V_{aperture}$ for electrostatic shielding of the collectors and the suppressor grid G6 is held at -15 volts to ensure that no ambient electrons strike the collector surfaces and that photo-emission from the collector surfaces are returned to the collector.

In all velocity measuring modes the drift velocity parallel to the sensor face is determined from two mutually perpendicular velocity components along the X and Z axes indicated in Figures 3 and 4. The axis designation system used in the figures assumes that the spacecraft is despun with the X axis pointing toward the center of the earth and the Z axis perpendicular to the orbit plane. In this configuration we use vertical and horizontal or pitch and yaw to denote the velocity along the X and Z axes, respectively. Figure 4 shows the collector configuration and the square entrance aperture which provides a simple linear geometric relationship between the angle of arrival of the plasma in the X-Y and Y-Z planes, the vertical and horizontal ion velocities, and the currents to the collector segments. If α



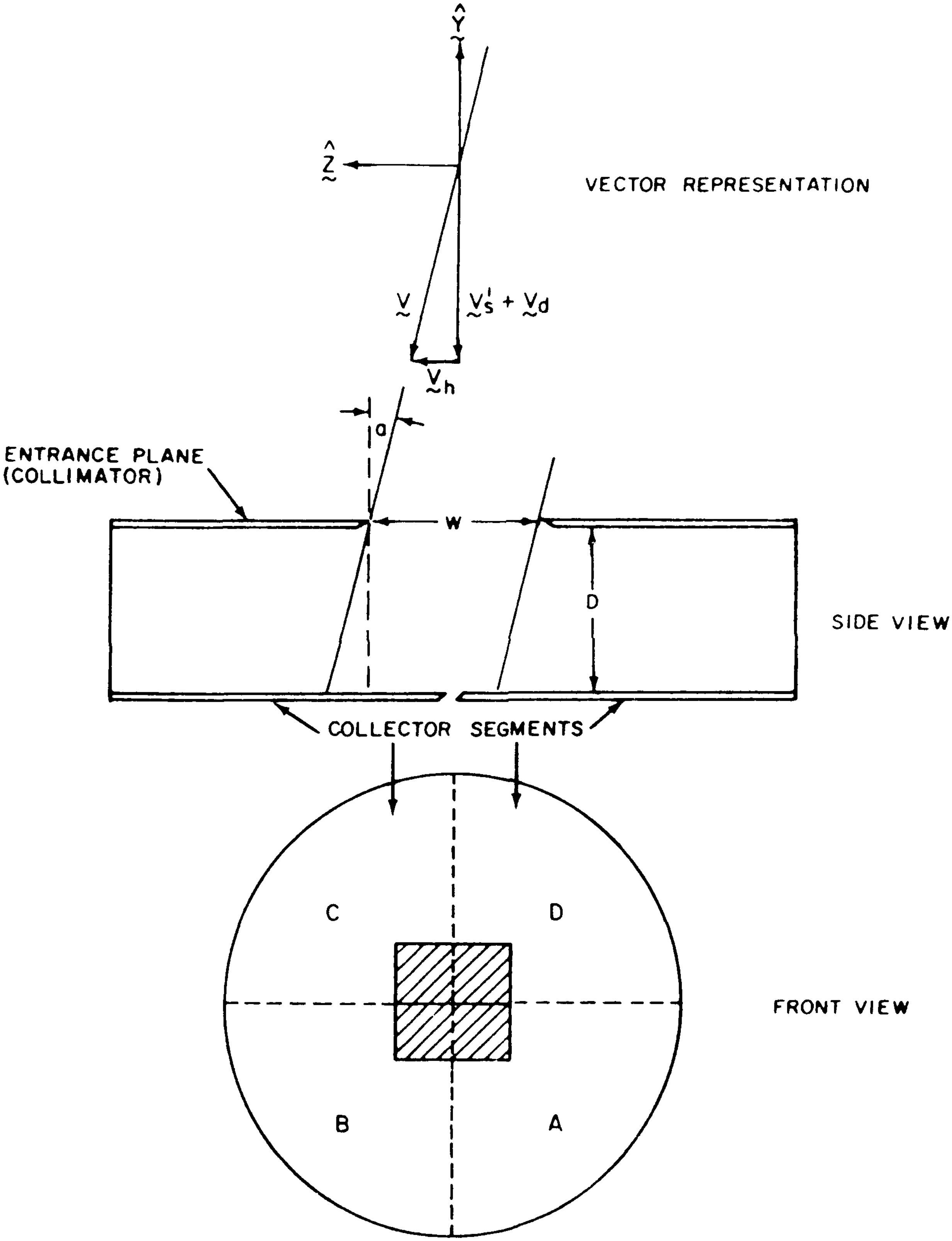
▨ -INSULATOR

GRID DESIGNATORS

G1 - INPUT
G2 - H+REPELLER
G3 - COLLIMATOR
G4 - SHIELD
G5 - SHIELD
G6 - SUPPRESSOR
C - COLLECTOR PLATES

(ALL 50 LINES/INCH)

DRIFT SENSOR CROSS-SECTION



DM COLLECTOR / APERTURE CONFIGURATION

Figure 4

is the horizontal arrival angle, then the horizontal ion velocity is given by

$$V_x = V_y \; Tan\, \alpha \tag{1}$$

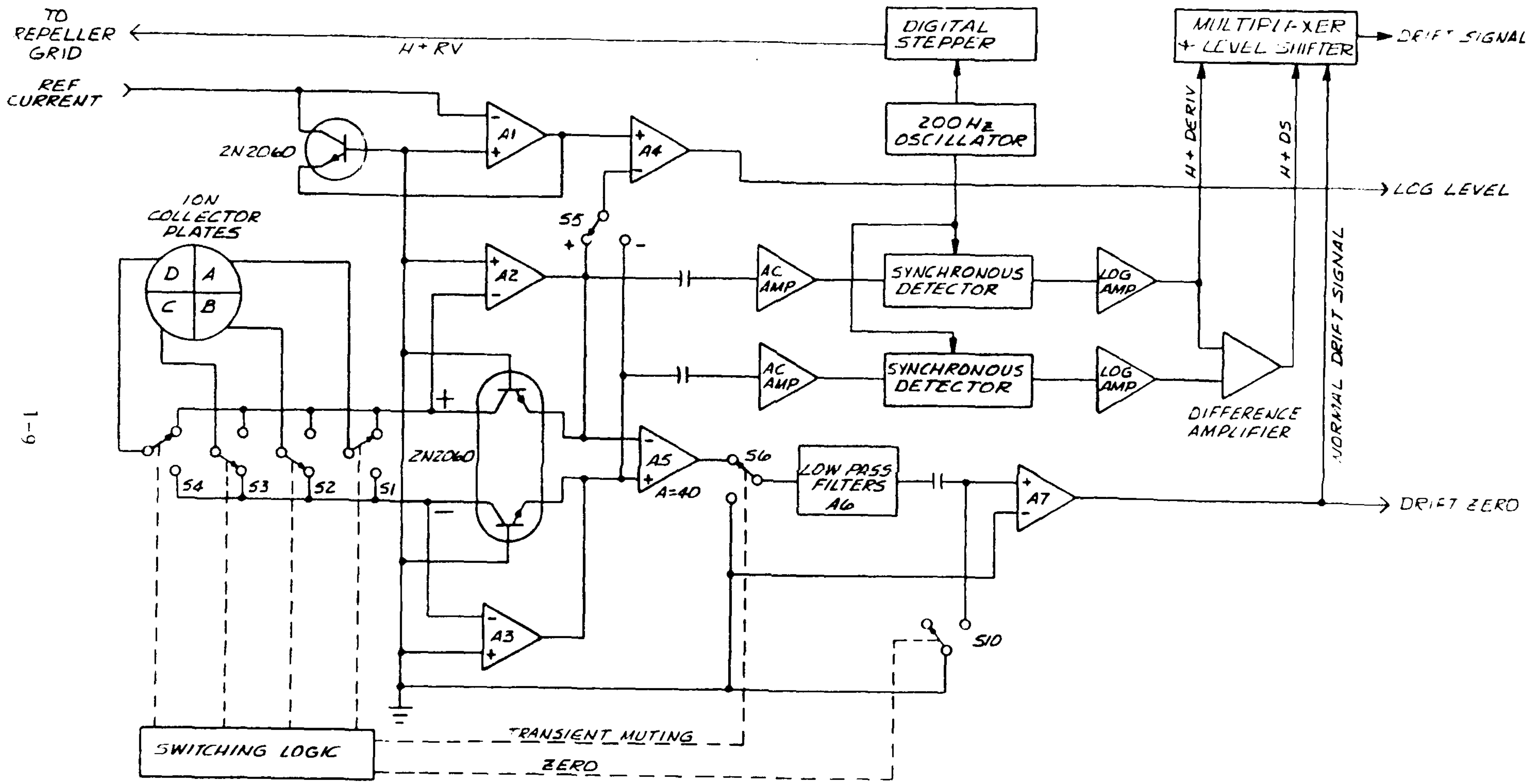
where V_y is the sum of the spacecraft velocity along the Y axis of the spacecraft and the particle drift velocity along this axis. The current to the collector is proportional to the collector area illuminated and it can easily be shown that to first order the ratio of the currents on collectors A and D to the currents on collectors B and C is proportional to $Tan\, \alpha$.

The current ratio is determined by connecting each collector pair to a logarithmic amplifier (see Figure 5) that provides the input to a linear difference amplifier. The ratio is obtained by a technique called "rezero and offset" which is insensitive to possible imbalances in the log amplifiers. The sequence of operations is synchronized to the SSIES data format in all modes.

2.1.1 DM–NORMAL Mode

At the beginning of each Cycle 1 (see Figure 2), the log amplifier inputs are configured to measure vertical arrival angles with the zero switch (S10) closed. The input capacitor to A7 charges to a voltage proportional to the vertical ion arrival angle. The output of A7 is always translated by +2.5 volts (nominal) and the nominal +2.5 volt "rezero" level is telemetered on the Multiplex output for housekeeping purposes.

At the first Electrometer/Amplifier conversion pulse (Word #2), the circuit is switched to the offset configuration by opening S10 and reversing the inputs to the log amplifier. The voltage out of the filter (A6) goes to the opposite polarity but with the same amplitude. Since the capacitor has its original charge from the rezero measurement, and the new voltage from the filter is nearly equal but opposite, the voltage into A7 is twice the voltage corresponding



DRIFT METER FUNCTIONAL DIAGRAM

Figure 5

to the arrival angle. By measuring the sum of the two current ratios in this manner the result is insensitive to the characteristics of the two log amplifiers.

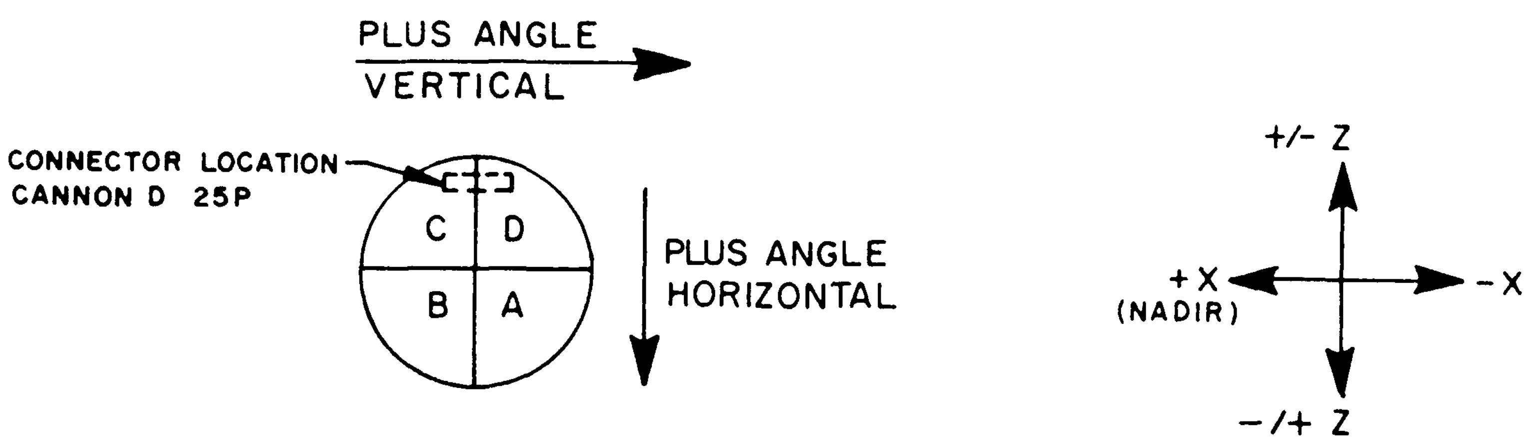
The vertical offset measurement is made at Word #6 (Drift Meter output), allowing ample settling time for transients generated by the collector switching. At the next Electrometer Amplifier conversion pulse (Word #7), the collector pairs are connected to the log amplifiers in the horizontal rezero configuration and the rezero and offset measurement sequence is repeated. The rezero and offset sequence is repeated 12 times per second with alternate vertical and horizontal offset measurements taken and telemetered via downlink format words 49–60 (Figure 2A). Word 49 and alternate words in each second will therefore always be vertical measurements. The DM output is filtered by a 120 Hz. filter in this mode.

Figure 6 illustrates how to determine the ion drift direction from the DM output. By definition, ion drift velocities in the directions of the arrows generate "plus" angles. A "plus" angle gives a DM output above +2.5 volts (nominal) and a "minus" angle gives a voltage below +2.5 volts.

Since the presence of H^+ as a significant percentage of the ambient ions has been seen to compromise the O^+ arrival angle measurements, a fixed repeller potential may be selected for G2 (0 to +3 volts in 0.5 volt increments) to exclude H^+.

2.1.2 DM – H^+ Mode

The flow velocity of light ions along the earth's magnetic field lines is measured using the same principles described above. However, we must now accommodate the fact that the light ions will have a much smaller signal than the heavier ions because they have a smaller concentration and a larger thermal velocity. The larger thermal velocity of the light ions means that the constant of proportionality between the tangent of the ion arrival angle and



DRIFT METER
ARRIVAL ANGLE POLARITY DEFINITION

Figure 6

collector current asymmetry will not be the same as that established for heavy ions. The constant can be established, however, if the signal from the light ions can be extracted from the larger heavy ion signal. This is achieved utilizing a modulation technique originally employed in the RPA on the NASA Atmosphere Explorer satellite for electronically taking the derivative of the characteristic RPA curve.

This technique employs a retarding voltage (H^+RV) applied to the repeller grid G2. The positive DC potential on G2 can be varied stepwise from a selected starting point (0, 1, 2, or 3 volts) for 9 steps at 0.2 volts per step. In addition to the positive DC potential, a 200 hz. square wave is applied to G2. Since the heavy ions (mass 16 and above) have about 5 ev and above energy with respect to the spacecraft, their ability to reach the collector is not affected by the H^+RV, but the contribution to the total signal from H^+ ions is repeatedly diminished and returned at the square wave frequency. Since the repeller grid G2 is located in front of the collimator (aperture) the modulation on the grid will not affect the arrival angle of the heavy ions, so no compensation grid is required. Thus the log amplifier outputs (A2 and A3) will be modulated at 200 hz. and the amplitude of the modulation will be proportional to the collector surface areas illuminated by the H^+ ions. The ratio of these amplitudes is proportional to their arrival angles.

The modulated outputs of the log amplifiers are amplified and synchronously detected. The H^+ derivative (H^+DERIV) output provides a signal proportional to the amplitude of the H^+ modulation from which the H^+ concentration can be derived. The H^+ drift signal (H^+DS) output is derived by comparing the modulated log amplifier outputs in a difference amplifier and is proportional to the H^+ arrival angle, either horizontal (H) or vertical (V) depending on which pairs of collectors are connected to the log amplifiers.

The H^+ Mode measurement sequence is four seconds long and begins at a T_0 Cycle 1 that is coincident with a 16 SECSYNC pulse. During the H^+ sequence, the data is sampled at the sample format (Fig. 2) word numbers shown and is telemetered 12 times per second via words 49–60 in the downlink format shown in Figure 2A.

Sample Format Word #	Downlink Format Word #	Second 1,5,9, 13, . . .	Second 2,6,10, 18, . . .	Second 3,7,11, 15, . . .	Second 4,8,12, 16, . . .
6	49	Offset(V)	Offset(V)	Offset(H)	Offset(H)
16	50	Offset(H)	Offset(H)	Offset(V)	Offset(V)
26	51	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
36	52	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
46	53	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
56	54	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
66	55	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
76	56	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
86	57	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
96	58	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
106	59	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)
116	60	H^+ DERIV(H)	H^+ DS(H)	H^+ DERIV(V)	H^+ DS(V)

At the beginning of each cycle, vertical (V) and horizontal (H) offset measurements are made as in the bulk motion measurements. The H^+ RV is held at the selected starting point until the end of sample #3. After sample #3 and subsequent samples, the H^+ RV is incremented by 0.2 volts. The 200 hz. modulation is applied after sample #2. The H^+ DERIV and H^+ DS outputs

are sampled alternately in the horizontal and vertical configurations as shown above. A 120 Hz. output filter is used.

Either a high or a low modulation level may be selected by command. The low level provides 50 mv. peak to peak during the H^+ DERIV measurements and 400 mv. during the H^+ DS measurements. The high level provides 100 mv. for H^+ DERIV and 800 mv. for H^+ DS.

2.1.3 DM- Fiba Mode

In this mode the DM output is continuously connected to the normal drift signal as in the NORMAL mode, but the rezero and offset sequence is changed to accommodate the comb filter bank that is used to extend the bandwidth of the transverse drift velocity measurements. The sequence is as shown below where V_R and H_R are vertical and horizontal rezero measurements respectively, V_O and H_O are the offset measurements and V_D and H_D are "deviation" measurements.

Sample Format Word #	Downlink Format Word #	Second 1,5, 9, . . .	Second 2,6, 10, . . .	Second 3,7, 11, . . .	Second 4,8, 12, . . .
6	49	V_D	H_D	H_D	V_D
16	50	V_D	H_D	H_D	V_D
26	51	V_D	H_D	H_D	V_D
36	52	V_D	H_D	H_D	V_D
46	53	H_R	H_D	V_R	V_D
56	54	H_R	H_D	V_R	V_D
66	55	H_O	H_D	V_O	V_D
76	56	H_O	H_D	V_O	V_D
86	57	H_D	H_D	V_D	V_D
96	58	H_D	H_D	V_D	V_D
106	59	H_D	H_D	V_D	V_D
116	60	H_D	H_D	V_D	V_D

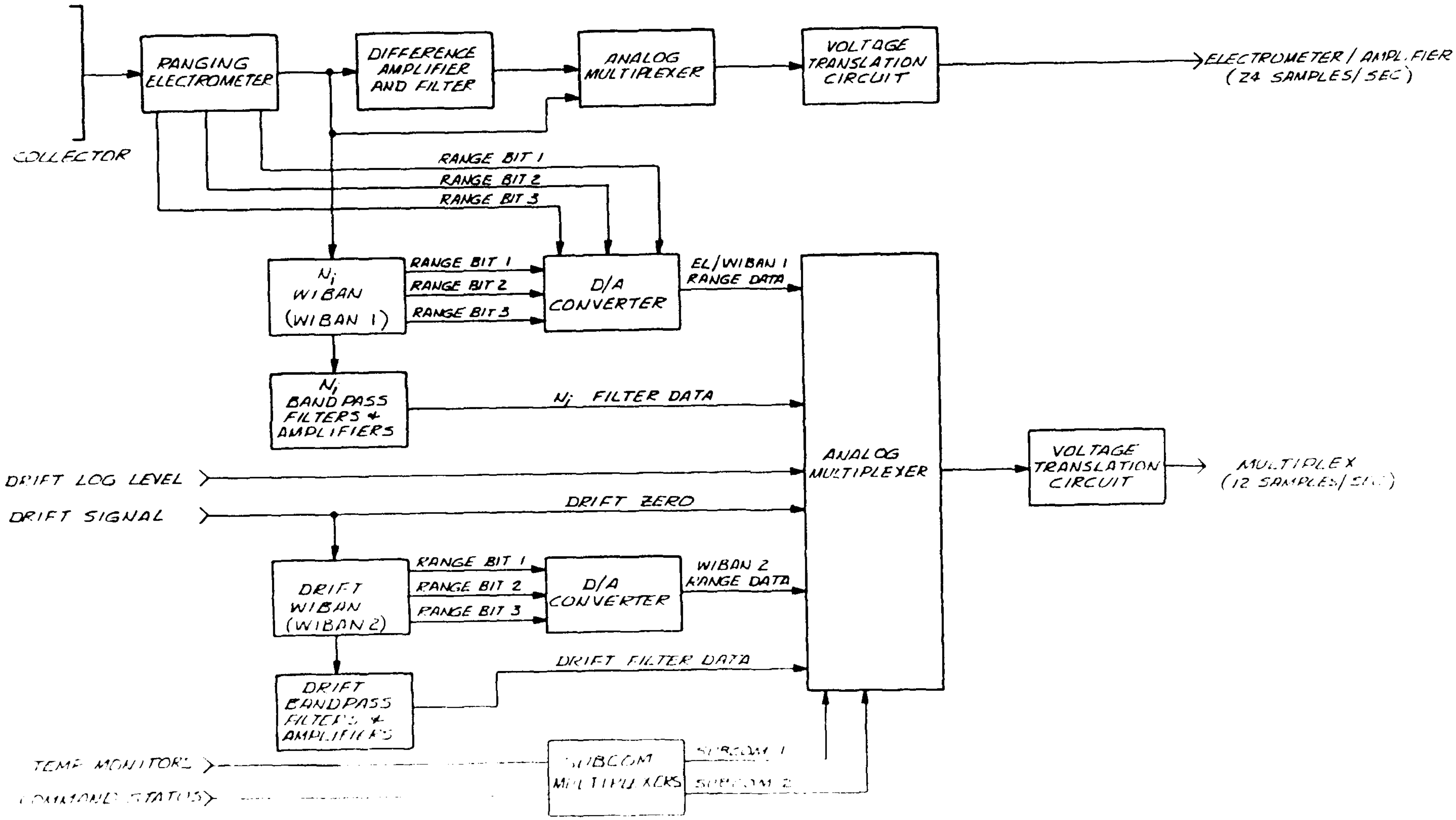
The rezero and offset measurements are made as described in 2.1 above for the NORMAL mode. After the last offset reading is taken (word #76), the collectors are returned to the rezero configuration, but the zero switch (S10) is left open until the next rezero sequence. The deviation measurements will therefore reflect any change in collector current ratio from the offset reading.

A 30 Hz. output filter is used during the rezero and offset readings and a 6 Hz. filter is used during deviation measurements.

To extend the bandwidth of the measurements, the output of A5 is AC coupled to a wide band ranging amplifier (WIBAN2) and then to a series of six bandpass filters and logarithmic amplifiers (Figure 7). WIBAN2 has 5 linear sensitivity ranges differing by a factor of $\sqrt{10}$ for each range change. The WIBAN2 sensitivity range can be automatically determined by the filter channel with the largest output voltage or fixed by ground command. In the automatic ranging mode, WIBAN2 is allowed to range during a window beginning at word #77 in odd seconds and ending at word #27 in even seconds (sample format word numbers). Ranging is disabled at all other times.

The bandpass filter frequencies are given below where the width of each filter is a factor of 2.4 between the 6 db. points:

Filter	Bandwidth
FIBA1	12 - 29 hz
FIBA2	29 - 69 hz
FIBA3	69 - 166 hz
FIBA4	166 - 398 hz
FIBA5	398 - 956 hz
FIBA6	956 - 2293 hz



SCINTILLATION METER / MULTIPLEX BLOCK DIAGRAM

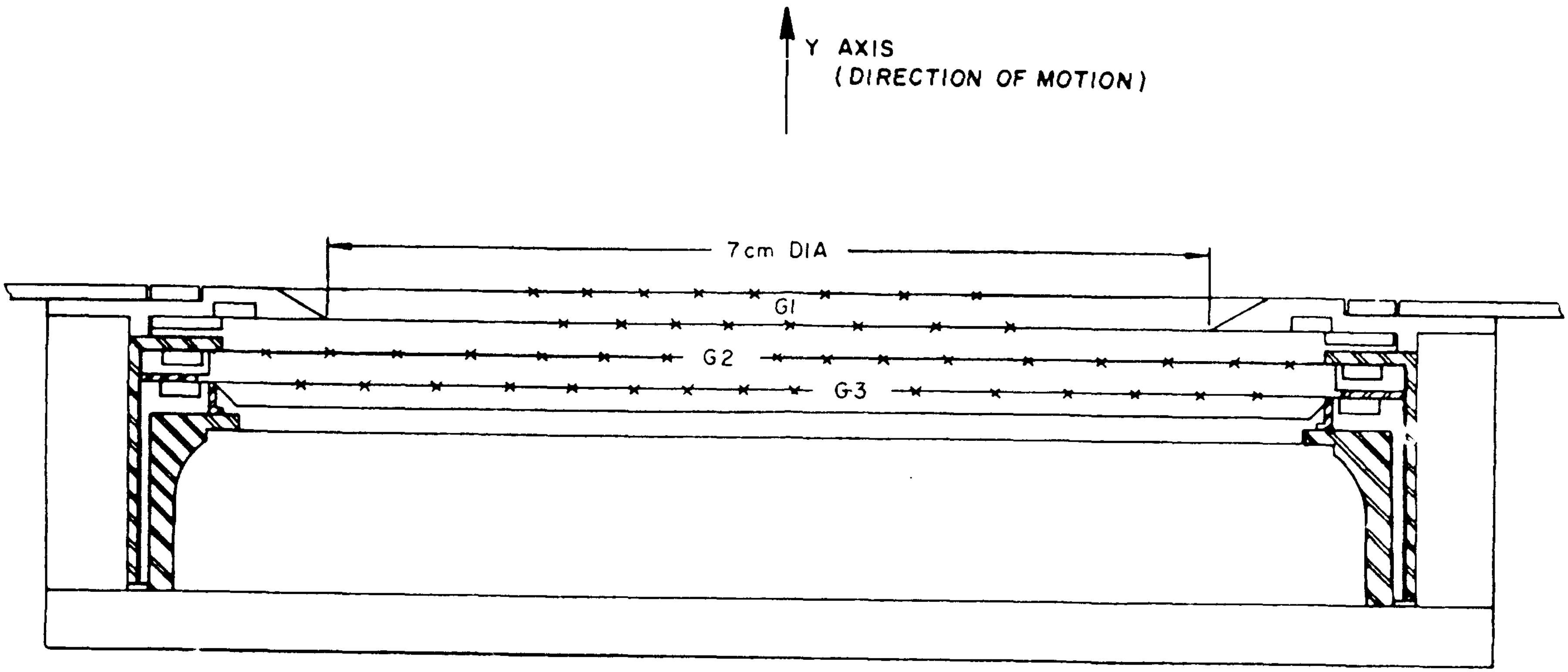
Each filter circuit consists of a logarithmic amplifier preceded by an active bandpass filter. Each log amplifier provides an output proportional to the log of the rms of the input signal. The useful dynamic range of each log amplifier is approximately 50 db with a sensitivity of 1.5 volts per decade (nominal). The filters are sampled once every two seconds on the MUX output as discussed below.

2.2 Scintillation Meter

The Scintillation Meter (SM) sensor is illustrated in Figure 8. The double input grid G1 is fixed at the $V_{aperture}$ potential. Grid G2 serves as an electron suppressor for the collector and also as an electron repeller for ambient electrons. Grid G3 provides electrostatic shielding for the collector. The collector is connected to a linear electrometer that measures the total ion current impinging on the collector (Figure 7). The electrometer has 5 linear sensitivity ranges and the sensitivity is automatically adjusted to maintain maximum sensitivity while staying within the telemetry band. The electrometer sensitivity on the most sensitive range is 6.32×10^{-9} amps/volt and decreases by a factor of $\sqrt{10}$ for each range change to 6.32×10^{-7} amps/volt on the least sensitive range.

In order to achieve higher sensitivity to change in N_i, the electrometer output is stored periodically at one terminal of a x10 difference amplifier and the live electrometer output is connected to the other terminal. The zero output of the difference amplifier is set to the middle of the telemetry band so that either positive or negative changes in N_i can be detected.

An analog multiplexer is used to automatically connect either the electrometer or amplifier to the telemeter (via a 12 hz Bessel filter) depending on the magnitude of the variations in N_i. The analog multiplexer is controlled by comparator circuits that monitor the amplifier output to determine if it is near the upper or lower telemetry band edge. When



- INSULATOR

GRID DESIGNATORS

G1 - INPUT (DUAL) } (ALL 50 LINES / INCH)
G2 - SUPPRESSOR
G3 - SHIELD

APERTURE – 38.5 cm^2
TRANSMISSION = 0.663
A_{eff} = 25.53 cm^2

SCINTILLATION METER SENSOR CROSS-SECTION

Figure

the amplifier exceeds either the upper or lower comparator limit, the electrometer is connected to the telemeter. (The amplifier is "zeroed" to the nominal +2.7 volt level continuously while the electrometer is connected to the telemeter.) If the amplifier again exceeds either comparator limit within one second, the electrometer is connected continuously to the telemeter until 8 T_0 cycle 1 pulses have elapsed (15 to 16 seconds). At the end of this period, the output is switched back to the amplifier. If over-range occurs again within 1 second, the output is switched back to electrometer for another 15 to 16 second period. If over-range does not occur during the 1 second period, the words remain on the amplifier until one of the following events occurs:

1. An amplifier over-range will switch the output to electrometer. The next T_0 CYCLE 1 pulse will initiate a new cycle.
2. After a 16 second period, the output is switched to electrometer for 2 samples.

The above events are flagged when they occur as follows:

EVENT	FLAG	DURATION
Amplifier to electrometer with no electrometer range change	0 volts	Either 1 or 2 samples
Electrometer range change (always causes an amplifier to electrometer switch)	Range Data (See below)	Either 1 or 2 samples
Electrometer to amplifier	+ 5.11 volts	1 sample

Whenever the electrometer changes range, a voltage level indicating the new range setting is output as indicated above (The range setting is also telemetered once every two seconds on the Multiplex output). The nominal output voltage levels versus electrometer range are as follows:

	Range	Nominal Voltage Level
1	6.32x105–94 A/V	0.26
2	2x105–84 A/V	0.22
3	6.32x105–84 A/V	0.20
4	2x105–74 A/V	0.16
5	6.32x105–74 A/V	0.12

(Note: The lower comparator limits are set above 0.26 volts and the upper comparator limits are set below 5 volts. This provides virtually unambiguous flag and range data since the amplifier output is constrained between the comparator limits as is the electrometer except for the bottom of range one and the top of range 5.)

The bandwidth of the ionospheric irregularity measurements is extended by AC coupling the electrometer output to a wide band ranging amplifier (WIBAN1) and then to a series of 6 bandpass filters and logarithmic amplifiers identical to those descibed for the Drift Meter above. WIBAN1 is allowed to range automatically from sample format word #61 to word #107 in each odd numbered second. Each filter output is sampled once per second on the MUX output.

2.3 Multiplex Output

Figure 7 shows a block diagram of the Multiplex (MUX) function and Table 1 defines the data multiplexing and sample times within the SSIES-2 data sample format (Figure 2) for each 128 second data block and the corresponding data downlink word numbers (Figure 2A). The outputs labelled N_iFIBAn and DMFIBAn are the outputs of the bandpass filters and amplifiers connected to the SM and DM respectively as previously discussed.

DSM2 MULTIPLEX DATA

SAMPLE WORD #	DOWNLINK WORD #	*Odd Seconds 1,3,5, ...	*Even Seconds 2,4,6, ...
10	61	DM FIBA 6	Subcom 1
11	62	DM FIBA 4	Subcom 2
20	63	DM FIBA 2	Log Level
21	64	DM FIBA 5	Drift Signal
30	65	DM FIBA 3	EL/WIBAN1 Range
31	66	DM FIBA 1	WIBAN2 Range
40	67	N_iFIBA 6	NiFIBA 6
41	68	NiFIBA 4	N_iFIBA 4
50	69	N_iFIBA 2	N_iFIBA 2
51	70	N_iFIBA 5	N_iFIBA 5
60	71	N_iFIBA 3	N_iFIBA 3
61	72	N_iFIBA 1	N_iFIBA 1

*Second #1 begins at a 16 SECSYNC pulse.

SECOND #	SUBCOM1 (DOWNLINK WORD #61	SUBCOM2 (DOWNLINK WORD #62
2,18,34, . . .	REG3A	REG3B
4,20,36, . . .	REG3C	REG3D
6,22,38, . . .	REG2A	REG2B
8,24,40, . . .	REG2C	REG2D
10,26,42, . . .	REG1A	REG1B
12,28,44, . . .	REG1C	REG1D
14,30,46, . . .	SENSTEMP	ELECTEMP
16,32,48, . . .	COMDATD (FIBA MODE)	RELAYFLG

TABLE 1

The EL/WIBAN1 range signal is a discrete voltage that indicates the sensitivity ranges of the SM electrometer and WIBAN1. The nominal output voltages versus ranges are as follows:

		Electrometer Range				
		1	2	3	4	5
WIBAN1	1	3.88	3.78	3.68	3.58	3.48
RANGE	2	3.08	2.98	2.88	2.78	2.68
	3	2.28	2.18	2.08	1.98	1.88
	4	1.49	1.39	1.29	1.19	1.09
	5	0.70	0.60	0.50	0.40	0.30

The nominal WIBAN2 Range output voltage versus WIBAN2 sensitivity range settings are:

WIBAN2 RANGE	OUTPUT VOLTAGE
1	0.00
2	0.27
3	0.54
4	0.80
5	1.08

The Drift Signal output is included as a housekeeping monitor of the nominal 2.5 volt DM rezero level in the NORMAL mode. In the other modes it is not sampled in the rezero configuration.

The Log Level signal monitors the DM log amplifier outputs primarily for housekeeping purposes. It can also be used to derive ion concentration. The DM mode

determines which collectors are connected to the log amplifier inputs as shown in the following matrix:

MODE	Second 2,6,10,14, . . .	Second 4,8,12,16, . . .
NORMAL	LLA, B&C	LLB, A&D
H^+	LLA, A&B	LLB, B&C
FIBA	LLA, C&D	LLB, A&D

The Subcom1 and Subcom2 outputs provide sensor and electronics temperature monitors, a flag for the SENPOT relay ($0V = V_{BIAS}$ mode, $+5.11V =$ SENPOT mode), the status of the DSM2 internal command registers and the status of the COMDATD line that is latched by the SSIES-2 main electronics package (MEP). The command register states versus commands are given in the following section.

2.4 Commands

The SSIES-2 receives the serial commands from the spacecraft. When a DSM2 command is detected, it is sent to the DSM2 via a four-line parallel data bus (COMDATA,B,C,D) and a three-line address bus (REGSTROBEA,B,C). The data on the COMDAT bus is stored in one of the three DSM2 command registers as shown in Table 2 when one of the REGSTROBE bits is asserted. After the data is stored in the register, the REGSTROBE bit is removed before the COMDAT data is changed to preclude disturbing the stored register contents.

The data stored in register 1 is used to control WIBAN2 range as previously discussed and the data in register 2 is used to control WIBAN1 range and the SENPOT/VBIAS mode latching relay. When one of the two relay commands is detected by the MEP, the command is sent to register 2. After a time period sufficient to ensure that the relay is magnetically

DSM2 COMMAND DEFINITION

REGSTROBE C	B	A	COMDAT D	C	B	A	MNEMONIC
0	0	1	0	0	0	0	WB2AUTO
0	0	1	1	0	0	0	WB2RNG1
0	0	1	1	0	0	1	WB2RNG2
0	0	1	1	0	1	0	WB2RNG3
0	0	1	1	0	1	1	WB2RNG4
0	0	1	1	1	0	0	WB2RNG5
0	1	0	0	0	0	0	WB1AUTO
0	1	0	1	0	0	0	WB1RNG1
0	1	0	1	0	0	1	WB1RNG2
0	1	0	1	0	1	0	WB1RNG3
0	1	0	1	0	1	1	WB1RNG4
0	1	0	1	1	0	0	WB1RNG5
0	1	0	1	1	0	1	SENPOT MODE
0	1	0	1	1	1	0	VBIAS MODE
1	0	0	0	0	0	0	DREP00
1	0	0	0	0	1	0	DREP10
1	0	0	0	0	1	1	DREP15
1	0	0	0	1	0	0	DREP20
1	0	0	0	1	0	1	DREP25
1	0	0	0	1	1	0	DREP30
1	0	0	1	0	0	0	0WIGLO
1	0	0	1	0	0	1	0WIGHI
1	0	0	1	0	1	0	1WIGLO
1	0	0	1	0	1	1	1WIGHI
1	0	0	1	1	0	0	2WIGLO
1	0	0	1	1	0	1	2WIGHI
1	0	0	1	1	1	0	3WIGLO
1	0	0	1	1	1	1	3WIGHI
0	0	0	1	0	0	0	FIBA MODE
0	0	0	0	0	0	0	NORMAL/H⁺ MODE

TABLE 2

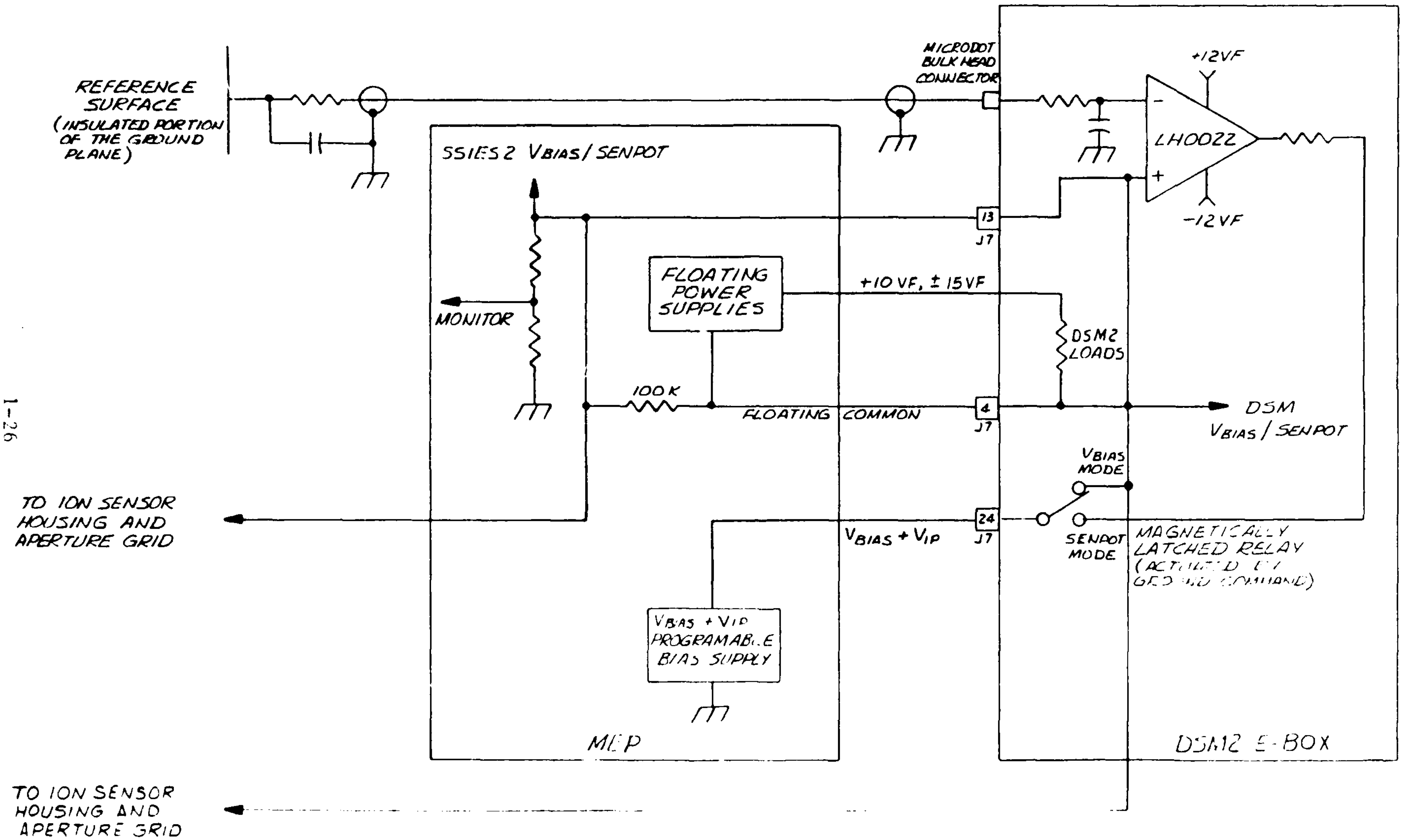
latched, register 2 is restored by the MEP to the state that was present prior to the execution of the relay command.

Register 3 is used in conjunction with the COMDATD line (the COMDAT lines are latched by the MEP) to establish the DM operating mode. If COMDATD is a logic "1", the FIBA mode is commanded and a fixed H^+ repeller voltage (DREP00–DREP30) must be selected and stored in register 3 to repel H^+ ions. (Note: The H^+ repeller voltage commands, 0WIGLO through 0WIGHI are not gated out by the hardware in the FIBA mode but should not normally be selected in this mode. These commands would only be useful in the FIBA mode as a diagnostic tool and should not be included in operational FIBA mode sequences.) If COMDATD is low and one of the fixed H^+ repeller voltage (DREP00–DREP30) is selected, the DM operates in the NORMAL mode. The DM is in the H^+ mode when COMDATD is low and one of the H^+ modulated voltage ramps (0WIGLO–3WIGHI) is selected and stored in register 3.

At power up and reset, the MEP initiate procedure automatically sets the registers and the latched COMDAT lines to all "0", i.e., WB2AUTO, WB1AUTO, DREP00, NORMAL/H^+ mode.

2.5 Sensor Potential

Figure 9 illustrates the SENPOT circuit that is included as an auxiliary means of establishing sensor potential. The reference surface is a segment of the aperture plane located near the Irregularity Sensor that is insulated from the sensor housings and insulated from the other part of the aperture plane. The main part of the aperture plane is tied electrically to the ion sensor housings. The reference surface is sized to collect enough ion current to comfortably allow the SENPOT circuit to operate over the available voltage range



DSM2 SENPOT CIRCUIT

(= −12 volts to +37 volts) with an ion density of > 100 cm^{-3} and a reference surface insulation resistance of > 10^{11} ohms.

The reference surface is connected to the non-inverting input of an FET-input operational amplifier that is powered by floating supplies referenced to the sensor potential. The high input impedance and low input bias current of the op-amp allows the ground plane to float at the potential at which equal ion and electron currents are collected, nominally −1 volt with respect to plasma potential. Since the op-amp must maintain equal voltages at both inputs, it will drive against the spacecraft ground (through the SSIES VBIAS + VIP supply connected to the op-amp output) until the voltage at the non-inverting input is at the ground plane potential. Since the output voltage swing of the op-amp is about (= 9 volts, the VBIAS + VIP supply connected to the output allows control of the sensor potential from about −12 volts to +37 volts with respect to spacecraft potential.

2.6 Mass/Weight

The measured mass/weight for the listed flight configuration instrument components are:

	Grams	Pounds
Sensor Assemblies - DM	678.1	1.49
- SM	689.8	1.52
- RPA	405.7	0.89
Aperture Plane	415.6	0.92
Sensor Mounting Bracket	289.6	0.64
Miscellaneous Hardware	48.4	0.11
Total Ion Sensor Array	2527.2	5.57
DSM Electronics Box	2553.7	5.62

2.7 Power Supplies

The SSIES-2 provides regulated voltages to the DSM2. The regulated voltages versus drain currents at 25°C are:

+ 12VF - 55 ma.

-12VF - 55 ma.

+ 12V - 1.5 ma

-12V - 1.5 ma.

The increase in current due to temperature variations within the specified temperature extremes is less than 25%. The SENPOT relay coils draw about 25 ma. from the + 12VF line when either the SENPOT mode or VBIAS mode command is asserted. These commands are only asserted for a short time by the SSIES-2 microprocessor to magnetically latch the relay and then the relay coil power is removed.

References

[1] Zuccaro, D. R., and B. J. Holt, "A Technique for Establishing a Reference Potential on Satellites in Planetary Ionospheres", *J. Geophys. Res.*, *87*, 8327 - 8329, 1982

SECTION 2

SPACECRAFT-LEVEL INSTRUMENT TESTING, INSTRUMENT HANDLING AND SAFETY

SPACECRAFT-LEVEL INSTRUMENT TESTING

INSTRUMENT HANDLING AND SAFETY

1.0 General

This section defines the three types of electrical tests planned for the DSM2 after installation on the spacecraft. Paragraph 5.0 indicates the times during the spacecraft-level test flow that the tests should be performed. The required sensor mechanical alignments versus spacecraft test flow are also indicated.

2.0 Electrical Performance Evaluation Test (EPET)

The EPET provides an automated test procedure for testing instrument response in each major operating mode. Although there are only three distinct DSM2 modes (FIBA, H^+ or NORMAL), there are other modal parameters that may be selected by command. Each of the DSM2 commands should be executed at some point during the EPET and the command monitor checked to verify each command. Additionally, several tests will be defined for the EPET wherein the DSM2 is commanded to a specified mode, 32 consecutive seconds of data are stored and the data are printed out in a specified format. The instrument performance evaluation will be based on visual observation of the printed data. The EPET can be performed either with or without stimulation.

The time required for the EPET will be primarily determined by the speed of the spacecraft ground check-out computer system.

3.0 Stimulation

A battery powered stimulation unit is used to provide test currents to the DSM2 sensors. The stimulation unit attaches to the protective covers that are installed over the sensor input apertures. The test currents are injected by probes that screw into the front face

of the sensor and make contact with the collectors. The stimulation unit requires ~6 inches clearance in front of the sensor aperture plane for installation. The planned usage of the stimulation unit is limited to tests performed with attending UTD personnel. Installation or removal of the stimulation unit will require approximately 30 minutes.

4.0 Sensor Grid Test

The sensor grid test is performed by UTD personnel after final instrument installation on the spacecraft and completion of environmental testing. The test consists of attaching test probes to the internal sensor grids and verifying the correct grid potentials.

5.0 DSM2 Spacecraft-Level Test Requirements

SPACECRAFT ACTIVITY	INSTRUMENT TESTS REQUIRED
1. Instrument Integration	Initial Power Turn On (IPTO)
2. System Electrical Performance Evaluation Test (SEPET)	EPET With Stimulation
3. Temperature Testing	EPET
4. Vacuum Testing	EPET
5. Pre-vibration/Post-vacuum	Sensor Alignment
6. EMI/RFI Testing	EPET
7. Vibration Testing	EPET
8. Post-vibration	Sensor Alignment Check
9. Final Clean-up And Test	a. EPET With Stimulation
	b. Sensor Grid Test
10. Pre-shipment Tests	EPET
11. WTR Testing	EPET

6.0 Instrument Handling and Safety

6.1 Protective sensor covers should be utilized whenever sensors are installed (except during EMI and vibration testing) to prevent particulate contamination from entering the sensor entrance apertures and to prevent physical damage to the exposed entrance grids. Stimulus probes may be installed with the protective covers in place. Special gold-plated aperture covers are provided for thermal vacuum testing.

6.2 Most of the exterior of the instrument is painted with Chemglaze 306 flat black paint and should receive "white-glove" treatment and minimum handling. The Chemglaze paint is attacked (expanded) by almost all common cleaning solvents (alcohol, acetone, freon, Mek, etc.). UTD should be consulted prior to any proposed instrument cleaning operation.

6.3 Always minimize handling of gold plated surfaces and utilize approved gloves when handling is necessary.

7.0 Red Tag Items

The two protective covers over the sensor apertures will be removed at the latest practical time at WTR. Captive hardware (2-56 screws) is used for attaching the protective covers to the sensor face. After removal of the protective covers, gold plated 2-56 screws must be installed in the sensor face to fill the holes.

SECTION 3

DIAGRAMS, SCHEMATICS, DRAWINGS

DSM2 DRAWING LIST

- TOP ASSEMBLIES -

133-113	Sensor installation dwg.
133-704	Electronics box assy
PL133-704	" " "
133-702	Scintillation Meter sensor head assy
PL133-702	" " " " "
133-701	Drift sensor head assy
PL133-701	" " " "
133-700	Ion sensor array
133-775	DSM2/SSIES-2 Intra-instrument cables

- SUBASSEMBLIES -

DSM2-1	Duct Ranging Amplifier	
	Board assy	133-730
	Part list	PL133-730
	Schematic	133-728
	Wire list	133-732
DSM2-2	Wide Band Amplifier 1	
	Board assy	133-711
	Part list	PL133-711
	Schematic	133-709
	Wire list	133-713
DSM2-3	Bandpass Amplifier - N_iFIBA 1,3,5	
	Board assy	133-707
	Part list	PL133-707/3
	Schematic	133-162
DSM2-4	Bandpass Amplifier - N_iFIBA 2,4,6	
	Board assy	133-707
	Part list	PL133-707/4
	Schematic	133-162
DSM2-5	Duct Amplifier and Logic	
	Board assy	133-745
	Part list	PL133-745
	Schematic	133-743
	Wire list	133-747

DSM2-6	FIBA Amplifiers	
	Board assy	133-716
	Part list	PL133-716
	Schematic	133-714
DSM2-7	Analog Level Shifters	
	Board assy	133-740
	Part list	PL133-740
	Schematic	133-738
	Wire list	133-742
DSM2-8	Interface Buffer	
	Board assy	133-764
	Part list	PL133-764
	Schematic	133-762
DSM2-9	Bandpass Amplifier - DM Fiba 1,3,5	
	Board assy	133-707
	Part list	PL133-707/9
	Schematic	133-705
DSM2-10	Bandpass Amplifier DM Fiba 2,4,6	
	Board assy	133-707
	Part list	PL133-707/10
	Schematic	133-705
DSM2-11	Wide Band Amplifier 2	
	Board assy	133-720
	Part list	PL133-720
	Schematic	133-718
	Wire list	133-722
DSM2-12	Drift H + Detector	
	Board assy	133-735
	Part list	PL133-735
	Schematic	133-733
	Wire list	133-737
DSM2-13	Drift Ranging Amplifier	
	Board assy	133-759
	Part list	PL133-759
	Schematic	133-757
	Wire list	133-761

DSM2-14	Drift Amplifier		
	Board assy	133-755	
	Part list	PL133-755	
	Schematic	133-753	
DSM2-15	Drift Electometer		
	Board assy	133-750	
	Part List	PL133-750	
	Schematic	133-748	
DSM2-16	Duct Electrometer		
	Board assy	133-725	
	Part list	PL133-725	
	Schematic	133-723	